Technical Disclosure Commons

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Plumbing Line Freeze Protection

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Title:

Plumbing Line Freeze Protection

Abstract:

Disclosed is an electronically controlled plumbing fixture comprising an electronic valve, temperature sensor, and processor. The system is capable of measuring and predicting the temperature of a fluid in a plumbing line and opening the electronic valve and allowing the fluid to flow within the plumbing line when the system determines that the fluid may freeze and cause an issue in the plumbing line.

Invention:

When pipes get too cold, then can freeze and burst. This can result in substantial water damage which can be very costly. This occurs during extreme cold spells in winter but may also occur if a furnace stops functioning even in more typical weather.
Existing solutions require human intervention. Someone has to either shut off the water or turn on the faucet manually to keep water moving so it cannot freeze in the pipes.

Even if someone is available to intervene, they don't necessarily know that they should. It may be plenty warm in a bedroom or living room, but dangerously cold in a cabinet on an outside wall where plumbing fixtures could freeze.
The connected home affords more benefits too. The presence of multiple devices with temperature sensors allows for the system to get a more complete view of what is going on in the home. This allows for action to be taken remotely. Even if the temperature by the fixture is acceptable, it may not be on plumbing lines running to the fixture which may be susceptible to freeze. Trickling water on that fixture could prevent a problem some distance away. The aggregation of information allows for intelligent decision making.
There is also not a good way to know where your plumbing system is most at risk without studying how the plumbing lines are run (relative to inner/outer walls).
Because this is not visible apparent, this can be hard to do. By characterizing the system, this invention can point to specific problem areas so they can be studied and avoid the need to analyze all the plumbing lines in the home.

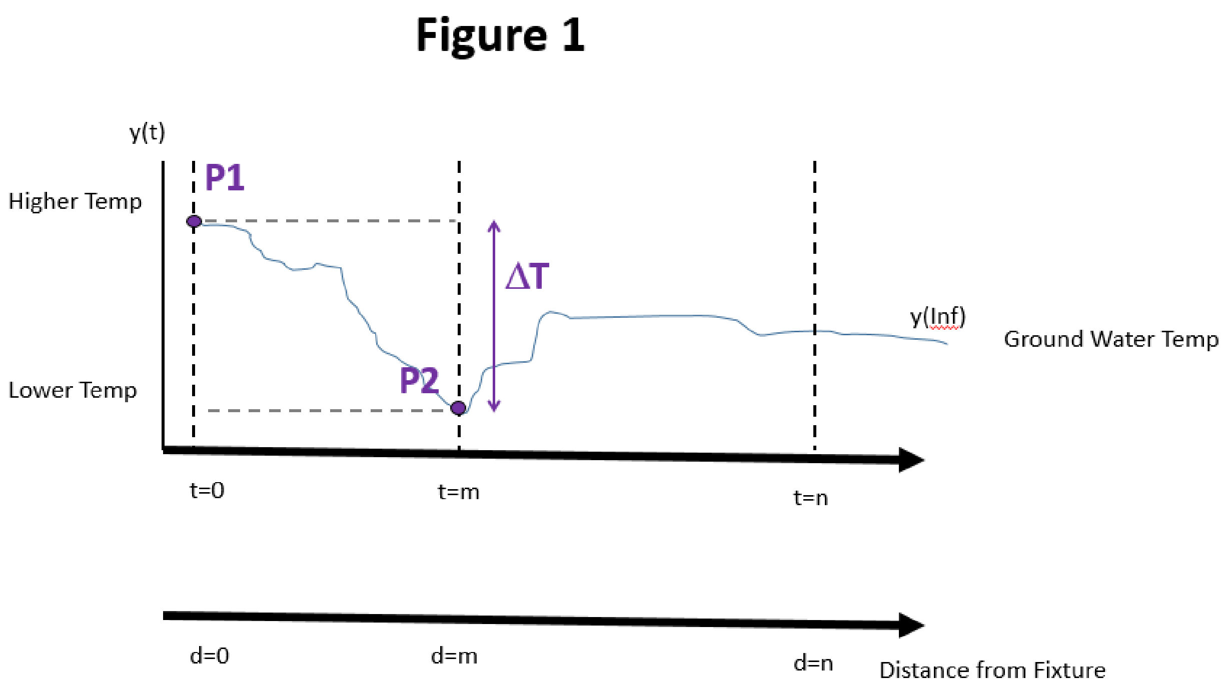

Figure 1 depicts the measured temperature of water using an in line temperature sensor while the water line is purged.

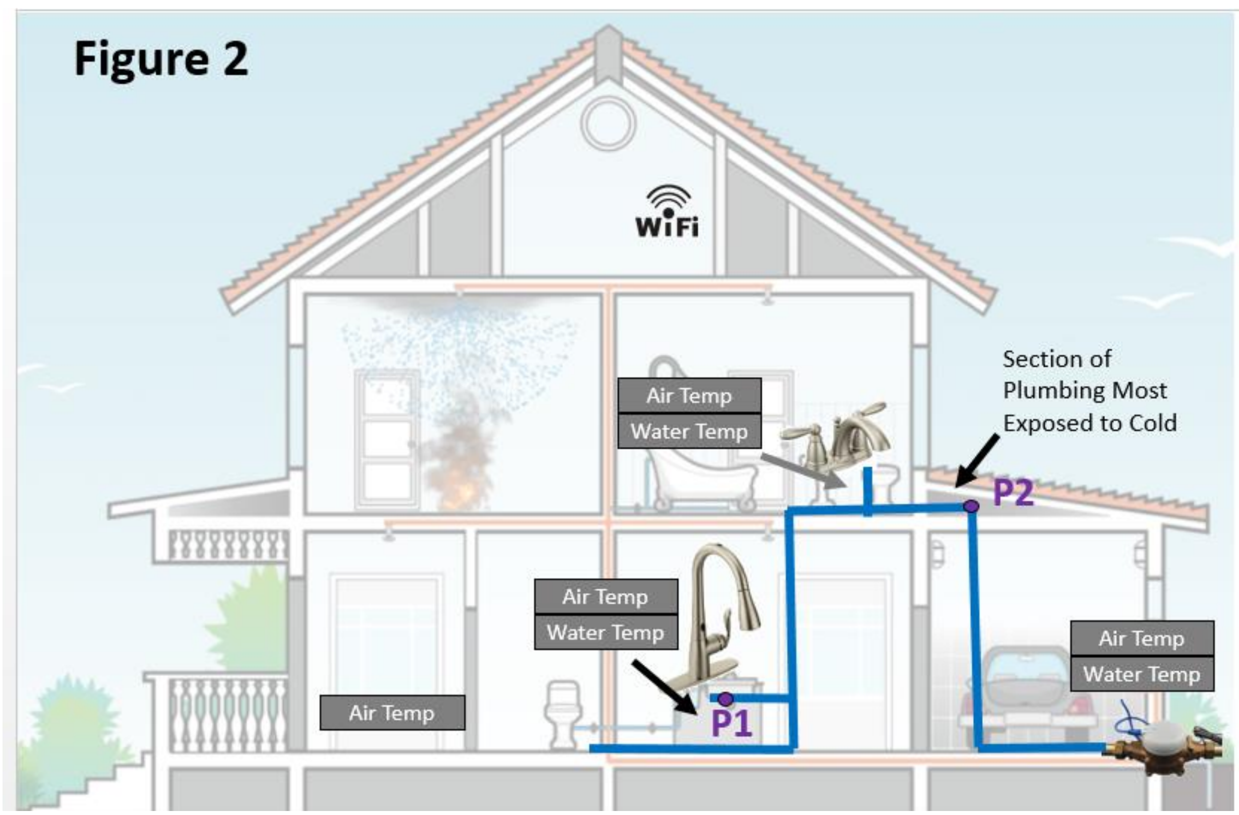

Figure 2 – An illustrate of a home with possible plumbing lines depicted.

Freeze protection detects dangerous conditions and automatically begins flowing water to avoid freezing. It consists of the following:

- A plumbing fixture capable of turning on/off water
- A motor or other device capable of enabling a small stream of water
    - This could be a motor that can be used to open the waterway a fractional amount (e.g. proportional value or geared motor valve).
    - This could be a separate smaller plumbing path with a solenoid that is open/closed. This exists less typically in currently plumbing.
- Electronic control of said plumbing fixture so that the stream of water can be controlled
- Temperature sensor(s)
    - An temperature sensor to measure the ambient air temp at the fixture
    - A temperature sensor to measure the temperature of water in the pipe at the fixture.
    - This invention could include 1 or both of these depending on how implemented. One embodiment is to use both so the air temp can be measured against the threshold while the water temperature sensor can be used to learn the appropriate level to set the threshold.
    - Another temperature (e.g. the temperature of a silicon substrate) can also be measured and used as a proxy. This can lower costs by making use of an otherwise present temp sensor and not require additional hardware or hardware interfacing to it.
- A microprocessor
- A means for the microprocessor to read the temperature
- A means for the microprocessor to drive the motor
- A user interface to allow a user to enable/disable the freeze protection feature to prevent it from automatically running water
- A means for setting a threshold for the temperature sensor which corresponds to a dangerous condition where pipes may freeze
    - This could be hard coded which may be appropriate for devices with predictable installation circumstances
    - This could be settable by the end user via an app or other interface
    - This could be learned by monitoring typical air/water temperature in static conditions to establish normal conditions and to set a threshold much below that
    - This could be learned by using an in water temperature sensor to profile the plumbing system. This is described later under “Plumbing System Analysis”. See that for more information:
- A method where the processor compares the current ambient air temperature against the threshold. If the temp is below the threshold, then the processor enables the small stream of water to prevent freezing. When the temperature returns above the threshold, the water can be stopped.
- Connection to weather information (optional)

- Additional remote temperature sensors (optional). These could be located on other fixtures or elsewhere in the plumbing system. They could also exist elsewhere in the house independent of the plumbing system.
- Additional electronic fixtures capable of communicating with the temp sensors and this fixture so that they too can turn on a small stream of water to prevent possible freeze. (optional)
- If additional connected fixtures are present, they can also be configured to run a small stream of water.

Plumbing System Analysis

Plumbing system analysis is a method to characterize a home plumbing system to understand risk of pipes freezing. The analysis can be used to set a threshold as was indicated previously. It can also be used to generate reports to the home owner to inform them of potential risks and relatively locations of those risks. This could help them understand where more insulation may be necessary. This consists of similar hardware as described for the Freeze Protection case (namely a plumbing fixture, air temp sensor, water temp sensor, and microprocessor). It additionally adds the following:

- This method can be run explicitly by the user when the plumbing system has not been used for a long time so that the water in the pipes reaches a steady state based on ambient conditions.
- Alternatively, this can be run implicitly by analyzing the water temperature as the fixture is used under normal conditions. The end user does not even need to know that it is happening. When run implicitly…
    - The line needs to be fully purged while the algorithm monitors temperature so that all water in the plumbing system has its temperature measured while it is flushed out. The algorithm can detect the completion of the purge by monitoring when the temperature stabilizes (to what will be the ground water temperature).
    - The algorithm needs to know if the plumbing system was idle or not. It is not enough to know if the fixture was run or not because other fixtures sharing the same pipes may also have been used (e.g. see the Kitchen and Bathroom faucet in Figure 2). This can be determined by measuring the temp data while the line is purged. If the time it takes to reach the steady state ground water temperature is among the longest seen, then it’s a sign that the plumbing system was unused. If it is faster than that, then the plumbing system was recently used (thus giving a head start on the purge) and the collected temp data should be discarded.
- The processor should execute a procedure as follows:

    - The temperature y(t) is measured while water is purged from the line. This measurement continues until all water has been purged which can be detected by noting when the water reaches steady state representative of the ground water temperature.
    - Collect the water temperature data as a function of time. See y(t) in Figure 1. This can then be mapped to relative distance to represent the location in the pipe that the measured water was previously sitting. See y(d) overlaid on the same axis in Figure 1. This initial temperature t(0) corresponds to the water temperature at the fixture: d(0). The lowest (or potentially highest in the case of hot summer weather) temperature is t(m) which corresponds to d(m) and is located wherever the plumbing line is most exposed to external elements (e.g. hot or cold outdoor weather). These two points are labeled as Point P1 and P2 in both Figure 1 and Figure 2.
    - Calculate the difference (□T) between P1 and P2 (see Figure 1). This difference can be used to understand how much colder another part of the plumbing system is relative to the point of temperature measurement. See □T in Figure 1. This temperature difference can be used to raise the alarm threshold to not only protect against freezing at the fixture location (Point 1) but also at the coldest point in the plumbing system leading up to the fixture (Point 2).
        - For example: Assume that 40 degrees is an appropriate ambient air temperature limit to run a small stream of water for freeze protection because of concern that pipes may freeze. If the worst case observed □T is 7 degrees colder (or warmer if being characterized in the summer), then it indicates that conditions exist where somewhere in the plumbing system the plumbing line is actually more at risk. To compensate, the limit would be raised from 40 degrees to 40+7=47 degrees under the logic that the conditions at this worst case location (Point 2) will reach the threshold of 40 degrees when the ambient air temperature at the fixture itself (Point 1) reaches 47 degrees.
- To exaggerate the influence of outdoor environmental conditions on the water contained in the plumbing system, data should be collected on very hot or cold days. Weather forecast data or other ambient air temperatures can be used to understand this. It’s also possible to monitor the amplitude of temp changes when collecting data to know if the outdoor weather temperatures are extreme or not. Knowing outdoor weather data makes it clear if the algorithm is searching for minimums (winter) or maximums (summer) and makes it easier to ignore opposite extremes that could be due to the plumbing system running near HVAC vents (e.g. winter maximums because of heat from the HVAC warming water in the plumbing line).
- Whereas this algorithm produces the following:
    - A temperature threshold limit derived from □T which can be used for freeze production.

- As a further outcome, the plumbing system analysis could be used to create a plumbing system profile to flag the risk of freezing on various legs and to note the relative position where the plumbing system is most at risk (e.g. approximately 40% of the way between the fixture and the cold water inlet). Data from multiple end fixtures could be merged to gain more insight into the home's plumbing system.
- The profile could be used to generate a countdown time for purging the water system (unrelated to freeze protection). This involves estimating the amount of time required for the water to complete purging and reach min/max temperature. This requires understanding where in the temperature profile (see Figure 1) the fixture temperature y(t) is at and using the historic data to know how long it takes to reach steady state t=n.